

APPLICATION
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TITLE: A COMMUNICATIONS SYSTEM

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A COMMUNICATIONS SYSTEM

This invention relates to communications systems and in particular wireless communication systems.

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PRIORITY TO OTHER APPLICATIONS

This application claims priority from and incorporates herein U.S. Provisional Application No. 60/426,862, filed November 15, 2002, and titled "Transporting Digital Data".

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BACKGROUND OF THE INVENTION

Wireless communication includes a number of standards, for example, the Advance Mobile Phone Service (AMPS), Global System for Mobile communications (GSM), Time Division Multiple Access (TDMA) standards and the like. Typically, when
15 communication standards are changed or become obsolete within a particular communications system, hardware associated with the obsolete standard is replaced. For example, a channel card is replaced.

To ensure reliability, communications systems require
20 redundancy in their architecture to ensure that no data is lost if any hardware unit fails. Typically, redundancy is accomplished by having redundant components for each key component.

It is an important object of the invention to provide an improved wireless software-defined signal processing system that has the flexibility to fully utilize channels based on the communication standard required. It is another object of the invention to provide a communications system that includes
5 redundancy based on the protocol requirements while minimizing the amount of hardware used.

BRIEF SUMMARY OF THE INVENTION

10 Traditional wireless communication systems, such as a basestation architecture, use channel cards, which provide the transmission and reception capability for a given number of channels for a particular wireless standard. In order to change standards, wireless providers must physically replace
15 the channel cards. For example, this may entail driving many miles to a radio tower that includes the channel cards. As service providers transition between communication standards, it is necessary over time to replace channel cards using the old standard with channel cards using the new standard as more
20 customers start using phones or other wireless devices that support the new standard. This is not only costly, requiring a person to drive-out to each to a radio tower every time the provider wants to re-apportion some of the spectrum in a given location, but it also results in inefficient spectrum

utilization. For example, providers are still required to support AMPS today, and apportion part of their spectrum for AMPS even though there is very little traffic on the AMPS channels.

5 In one aspect, the invention is a method for allocating channels. The method includes determining a communication standard used by a message and determining available channels. The method also includes allocating a channel based on the available channels and the communication standard used by the
10 message.

 In another aspect the invention is an apparatus for allocating channels. The apparatus includes a memory that stores executable instruction signals and a processor. The processor executes the instruction signals to determine a
15 communication standard used by a message, to determine available channels and to allocate a channel based on the available channels and the communication standard used by the message.

 In a still other aspect, the invention is an article that
20 includes a machine-readable medium that stores executable instruction signals for allocating channels. The instruction signals cause a machine to determine a communication standard used by a message, to determine available channels, and to

allocate a channel based on the available channels and the communication standard used by the message.

In another aspect the invention is a software-defined signal processing system. The system includes a controller
5 and a set of primary servers. Each primary server includes software required to execute a communications standard. The system also includes a back-up server that supports the set of primary servers in case of failure. The back-up server is configured to perform the functions of a failed server from
10 the set of primary servers when the failed server fails.

The aspects above may have one or more of the following features. The invention allows for the channels within a communications system to be dynamically chosen based on communications standard required by a message rather than
15 statically choosing the channel to uses a communications standard of only one standard thereby eliminating the requirement of someone physically traveling to remote locations within a communications network to replace hardware. The communication standard used by a channel is determined
20 dynamically as current usage patterns dictate rather than having the communication standard on a quasi-static channel preassigned as occurs through the use of traditional line cards.

The communications system also includes a set of generic servers that are backed-up by at least one generic server thereby saving cost in having a large number of servers that are specific to a particular communications standard.

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BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a block diagram of a wireless communication system;

FIG. 2 is a block diagram of a software-defined signal
10 processing system.

FIG. 3 is flowchart for allocating a channel; and

FIG. 4 is a block diagram of a computer system on which the process of FIG. 3 may be implemented.

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DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a wireless communications system 10 includes an antenna 12, a radio frequency (RF) interface 14, a digital RF transport mechanism 18, a software (SW) signal processing system 22, a core network 24 (e.g., a wireless
20 service provider) and a channel-allocation processor device 26. The RF interface 14 receives and transmits RF signals through antenna 12 using a up-converter 16a and an down-converter 16b. For example, when a signal is received, the

down-converter 16b converts the signal from an RF signal to an intermediate frequency (IF) or baseband signal and digitizes the resultant signal. When a signal is transmitted, the up-converter 16a converts the signal from a baseband or IF signal
 5 to an RF signal and amplifies the RF signal for transmission. The up-converter 16a and down-converter 16b use a block of spectrum that contains more than one channel.

The digital RF transport mechanism 18 transports digital samples between the RF interface 14 and the software-defined
 10 signal processing system 22. In one embodiment, the RF transport mechanism 18 may be include fiber lines extending over many miles with a network interface that are connected to the software-defined signal processing system. In another embodiment, transport mechanism 18 includes a peripheral
 15 component interconnect (PCI) card having an analog-to-digital (A/D) converter and a digital-to-analog converter (D/A) on the PCI card, which transports the data into a software-defined signal processing system via the PCI bus.

The software-defined signal processing system 22
 20 processes the digitized signals in accordance with the specification for one or more communication standards for signals received from internal network 24 or signals processed for the internal network. The particular processing being performed by the system 22 is to define generic servers by

loading onto generic servers software specific to a
communication standard required by the communications system

10. Thus, system 22 can be used with multiple communication
standards using the same hardware. An example of the

5 software-defined signal processing system and wireless
communication system are found in U.S. Patent 6,584,146
entitled "SYSTEMS AND METHODS FOR WIRELESS COMMUNICATION", by
Vanu Bose et al., which is incorporated in its entirety
herein.

10 Referring to FIG. 2, software-defined signal processing
system 22 includes a controller 30 and clusters (e.g., cluster
36a and cluster 36b). Each cluster contains primary servers
(e.g., primary server 38a, primary server 38b, primary server
38c, primary server 38d, primary server 38e and primary server
15 38f). Each primary server 38a-38f is loaded with the
applicable software (i.e, software compliant with the
appropriate communications standard) by the controller 30 from
a central server (not shown). The applicable software
includes files, libraries and the like required to execute a
20 particular communications standard. Therefore, each primary
server 38-38f is generic and independent with respect to any
particular communications standard.

Software-defined signal processing system 22 also
includes a back-up controller 32 and back-up servers (e.g.

back-up server 40a and back-up server 40b). Backup-controller 32 is fully redundant to controller 30. For example, if controller 30 fails, back-up controller 30 performs the functions of the controller. Backup-server 40a provides redundancy to primary servers 38a-38f and back-up server 40b provides redundancy to primary servers 38a-38f. Back-up server 40a and back-up server 40b are assigned to primary servers 38a-38c and primary servers 38d-38f respectively by controller 30a. The redundancy plan of which back-up server supports which primary servers is periodically updated as load shifts over the course of time. Each backup server 40a and 40b preallocates all software objects, network connections, and memory buffers needed to mirror the processing of the primary server, but does not initiate any processing. This enables a single server to act as backup for a number of primary servers without CPU load limitation, and to quickly begin processing if any of the primaries fail. After a primary server fails and its backup server is activated, the controller 30 reallocates each of the primary servers previously assigned to that backup server to a different backup server.

The channel-allocation process device 26 includes a database 82 that contains a list of the available channels. The channel-allocation process device 26 determines the

channel to use based on the channels that are available in the database 82 and the communication standard required to be supported and directs the signal processing system 22 to assign the signal to that channel.

5 Referring to FIG. 3, a process 50 is an exemplary process for allocating channels based on a communication standard used by the message and the channels available. Process 50 receives (54) a message (e.g., a call, traffic, short-messaging or text, a broadcast, housekeeping signal, intended
10 consumer signals and the like). The message may be a received message (i.e., a message received from RF interface 14) or a message to be transmitted (i.e., a message that will be sent to RF interface 14 for transmission). Each message is in a format compliant with a communications standard. For example,
15 AMPS, GSM or the like. Process 50 determines (58) the communications standard used by the message. Process 50 determines (62) the available channels. For example, channel-allocation device 26 reads database 82 which contains a list of available channels. Process 50 allocates (66) a channel.
20 For example, channel-allocation device 26 determines the bandwidth required from the bandwidth requirements of the communications standard, e.g., AMPS requires 30kHz bandwidth and GSM requires a 200kHz bandwidth. Channel-allocation device 26 determines the frequencies licensed to the user of

the message. Channel-allocation device 26 chooses from the list of available channels a channel that meets the frequency and bandwidth requirements. Process 50 sends (70) an instruction to use the allocated channel. For example,
5 channel-allocation processing device 26 sends an instruction to the SW-defined signal processing device 22 which in turn sends a message to a mobile device to use the allocated channel. Process 50 continues allocating channels as messages are received. Using process 50 and dynamically responding to
10 the offered load of messages, the spectrum is utilized in the most efficient manner given the current usage pattern.

For example, a common transition that some providers are currently undergoing is upgrading 800 MHz analog cellular systems to 800 MHz GSM systems. While the GSM traffic is
15 quickly overtaking the analog traffic, providers are required by applicable law to support AMPS for several more years, and also have a few customers with unique needs that are best served by the analog system. Typically, a small number of frequencies are reserved for AMPS, and the rest are
20 transitioned over to GSM by adding GSM channel cards as the GSM traffic grows. The AMPS channels are dormant most of the time, except for occasional roaming traffic or occasional use by the few subscribers that still use analog phones.

Using process 50, AMPS could continue to be supported without having to waste parts of the spectrum by statically assigning voice channels to the AMPS system.

FIG. 4 shows one example of the channel-allocation processing device 26. Device 26 includes a processor 74 for allocating channels, a volatile memory 79, and a non-volatile memory 81 (e.g., hard disk). Non-volatile memory 81 stores operating system 83, data 84 that includes data related to wireless communication standards, allocated channels and unallocated channels. Non-volatile memory also includes computer instructions 82 which are executed by processor 74 out of volatile memory 79 to perform process 50. In one embodiment, computer instructions include executable instruction signals.

Process 50 is not limited to use with the hardware and software of FIG. 4; process 50 may find applicability in any computing or processing environment and with any type of machine that is capable of running a computer program.

Process 50 may be implemented in hardware, software, or a combination of the two. Process 50 may be implemented in computer programs executed on programmable computers/machines that each include a processor, a storage medium/article of manufacture readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one

input device, and one or more output devices. Program code may be applied to data entered using an input device to perform process 50 and to generate output information.

Each such program may be implemented in a high level
5 procedural or objected-oriented programming language to communicate with a computer system. However, the programs can be implemented in assembly or machine language. The language may be a compiled or an interpreted language. Each computer program may be stored on a storage medium (article) or device
10 (e.g., CD-ROM, hard disk, or magnetic diskette) that is readable by a general or special purpose programmable computer for configuring and operating the computer when the storage medium or device is read by the computer to perform process 50. Process 50 may also be implemented as a machine-readable
15 storage medium, configured with a computer program, where upon execution, instructions in the computer program cause the computer to operate in accordance with process 50.

The invention is not limited to the specific embodiments described herein. The invention is not limited to the
20 specific processing order of FIG. 3. Rather, the blocks of FIG. 3 may be re-ordered, as necessary, to achieve the results set forth above. The channel-allocation processing device is not limited to interfacing with one software defined signal processing system. Rather, the channel-allocation processing

device can perform channel allocation with multiple software defined signal processing systems, interfaced with one central database that handles channel assignment across all of the software defined processing systems. New communications
5 standards can be added as software upgrades and incorporated into the channel-allocation processing device.

In still other embodiments, the software-defined signal processing system 22 includes the channel-allocation processing device 26.

10 In still other embodiments, a back-up controller is not used and instead controller 30 includes redundancy features within the controller such as a mirrored set of servers and the like.

Other embodiments not described here are also within the
15 scope of the following claims. For example, there has been described novel apparatus and techniques for decoding convolutional codes. It is evident that those skilled in the art may now make numerous modifications and uses of and departures from specific apparatus and techniques herein
20 disclosed without departing from the inventive concepts. Consequently, the invention is to be construed as embracing each and every novel feature and novel combination of features present in or possessed by the apparatus and techniques herein

disclosed and limited solely by the spirit and scope of the appended claims.

What is claimed is: